US009185407B2

(12) **United States Patent**
Thangaraj et al.

(10) **Patent No.: US 9,185,407 B2**
(45) **Date of Patent: *Nov. 10, 2015**

(54) **DISPLAYING AUDIO DATA AND VIDEO DATA**

(71) Applicant: **Broadcom Corporation**, Irvine, CA (US)

(72) Inventors: **Arul Thangaraj**, Bangalore (IN); **Sandeep Bhatia**, Bangalore (IN); **Xuemen Chen**, Rancho Santa Fe, CA (US)

(73) Assignee: **BROADCOMM CORPORATION**, Irvine, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 99 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/709,309**

(22) Filed: **Dec. 10, 2012**

(65) **Prior Publication Data**

US 2013/0101050 A1 Apr. 25, 2013

Related U.S. Application Data

(63) Continuation of application No. 11/017,000, filed on Dec. 20, 2004, now Pat. No. 8,331,456, which is a continuation-in-part of application No. 10/259,032, filed on Sep. 27, 2002, now Pat. No. 7,953,194.

(51) **Int. Cl.**
H04N 7/12 (2006.01)
H04N 19/44 (2014.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 19/00533*** (2013.01); ***G11B 27/10*** (2013.01); ***H04N 7/56*** (2013.01); ***H04N 19/44*** (2014.11); ***H04N 21/2368*** (2013.01); ***H04N 21/4341*** (2013.01)

(58) **Field of Classification Search**
CPC . H04N 7/50; H04N 19/00533; H04N 5/0736; H04N 19/44; H04N 21/2368; H04N 21/4341; H04N 7/56; G11B 27/10
USPC 375/240.25
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,396,497 A * 3/1995 Veltman 375/240.25
5,808,722 A * 9/1998 Suzuki 352/12

(Continued)

OTHER PUBLICATIONS

US Notice of Allowance for U.S. Appl. No. 11/017,000 dated Aug. 8, 2012.

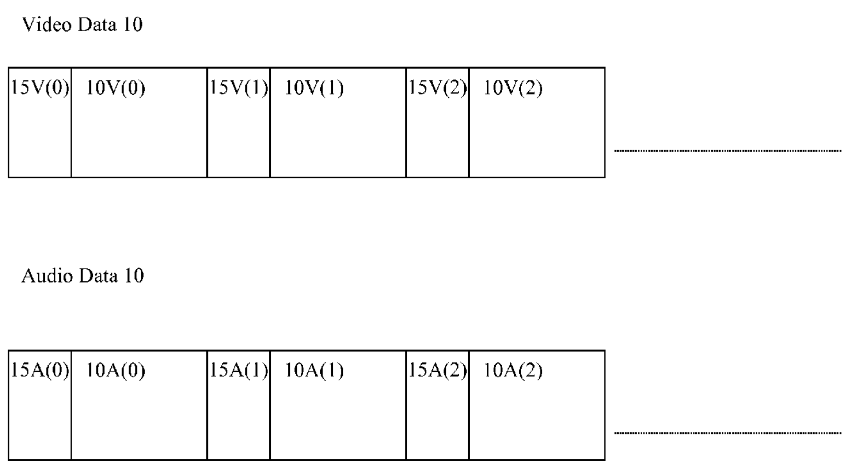
(Continued)

Primary Examiner — Jessica M Prince
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP; Christopher J. McKenna; Daniel E. Rose

(57) **ABSTRACT**

Presented herein are a system, method, and apparatus for audio and video synchronization. In one embodiment, there is presented a method for displaying audio data and video data. The method comprises examining a plurality of portions of the audio data, where each of said plurality of portions of audio data is associated with a time stamp; examining a plurality of portions of the video data, where each of said plurality of portions of the video data is associated with a time stamp; decoding one of the portions of the video data; and decoding one of the portions of the audio data while decoding the one of the portions of the video data. The difference between the time stamp associated with the one of the portions of the video data and the time stamp associated with the one of the portions of the audio data is within a certain margin of error from a predetermined offset.

16 Claims, 5 Drawing Sheets



(51) **Int. Cl.**

G11B 27/10	(2006.01)
H04N 7/56	(2006.01)
H04N 21/2368	(2011.01)
H04N 21/434	(2011.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,828,414	A	10/1998	Perkins et al.	
5,905,845	A *	5/1999	Okada et al.	386/244
6,262,776	B1 *	7/2001	Griffits	348/512
6,510,279	B1 *	1/2003	Morishita	386/203
6,556,250	B1	4/2003	Zeidler et al.	
6,611,624	B1	8/2003	Zhang et al.	
6,710,814	B1	3/2004	Ueno et al.	
6,754,280	B2	6/2004	Nguyen	
6,798,420	B1	9/2004	Xie	
6,801,544	B1	10/2004	Rijckaert et al.	
6,853,385	B1	2/2005	MacInnis et al.	
6,937,988	B1	8/2005	Hemkumar et al.	
6,975,324	B1	12/2005	Valmiki et al.	
7,123,307	B1	10/2006	Altmann	
7,268,826	B2 *	9/2007	Lundblad et al.	348/515
7,486,874	B2	2/2009	Yamauchi	
7,953,194	B2	5/2011	Chen et al.	
2002/0063796	A1	5/2002	Min	
2002/0087999	A1	7/2002	Kashima	
2002/0100064	A1	7/2002	Ward et al.	
2003/0002587	A1	1/2003	Nguyen	
2003/0066094	A1	4/2003	Schaar et al.	
2003/0097663	A1	5/2003	Puputti	
2003/0103766	A1 *	6/2003	Sugahara et al.	386/96
2003/0142752	A1	7/2003	Demas et al.	
2003/0165196	A1	9/2003	Demas et al.	
2004/0041946	A1 *	3/2004	Gries et al.	348/515
2004/0073949	A1	4/2004	Chen et al.	
2006/0034337	A1	2/2006	Ryu et al.	
2006/0098742	A1 *	5/2006	Meenakshisundaram et al.	375/240.27
2006/0098936	A1 *	5/2006	Ikeda et al.	386/46

OTHER PUBLICATIONS

US Notice of Allowance for U.S. Appl. No. 13/105,311 dated May 12, 2014.
US Office Action for U.S. Appl. No. 11/017,000 dated Jan. 4, 2011.
US Office Action for U.S. Appl. No. 11/017,000 dated Jan. 5, 2012.
US Office Action for U.S. Appl. No. 11/017,000 dated Aug. 19, 2008.
US Office Action for U.S. Appl. No. 11/017,000 dated Aug. 20, 2009.
US Office Action for U.S. Appl. No. 11/017,000 dated Aug. 9, 2011.
US Office Action for U.S. Appl. No. 13/105,311 dated Jan. 30, 2014.

* cited by examiner

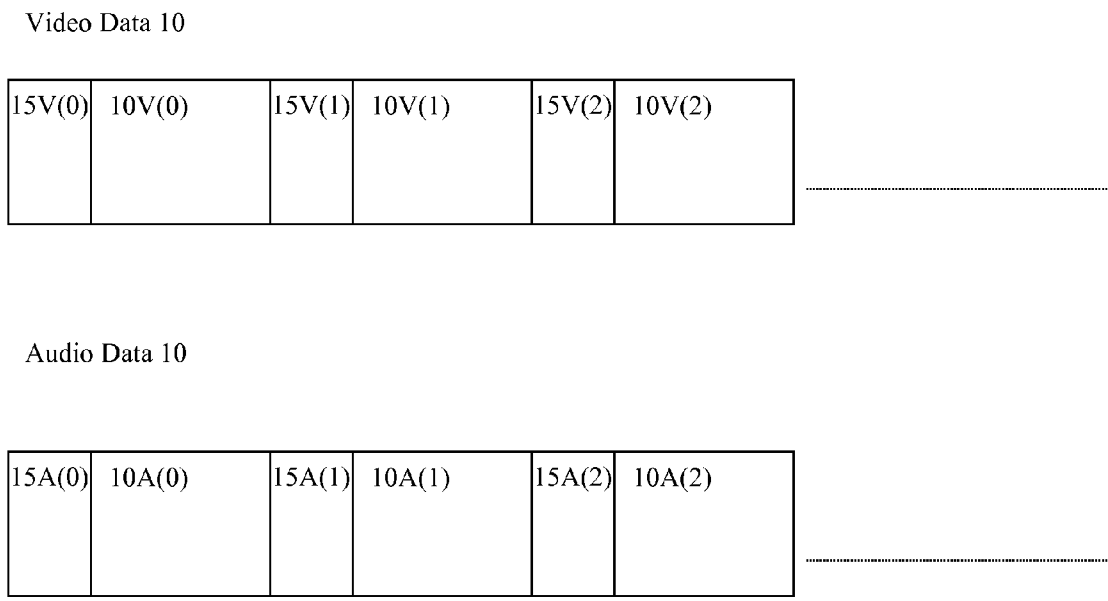


FIGURE 1

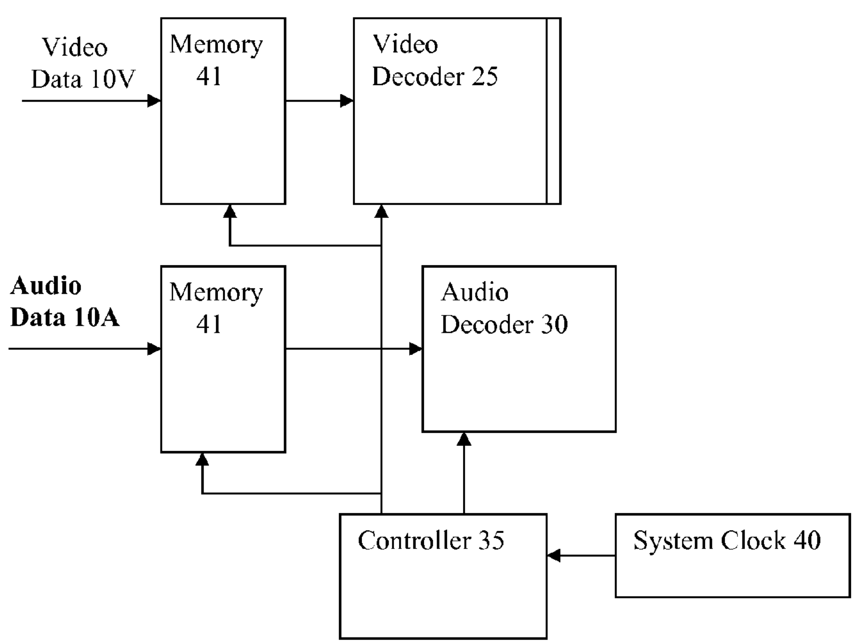


FIGURE 2

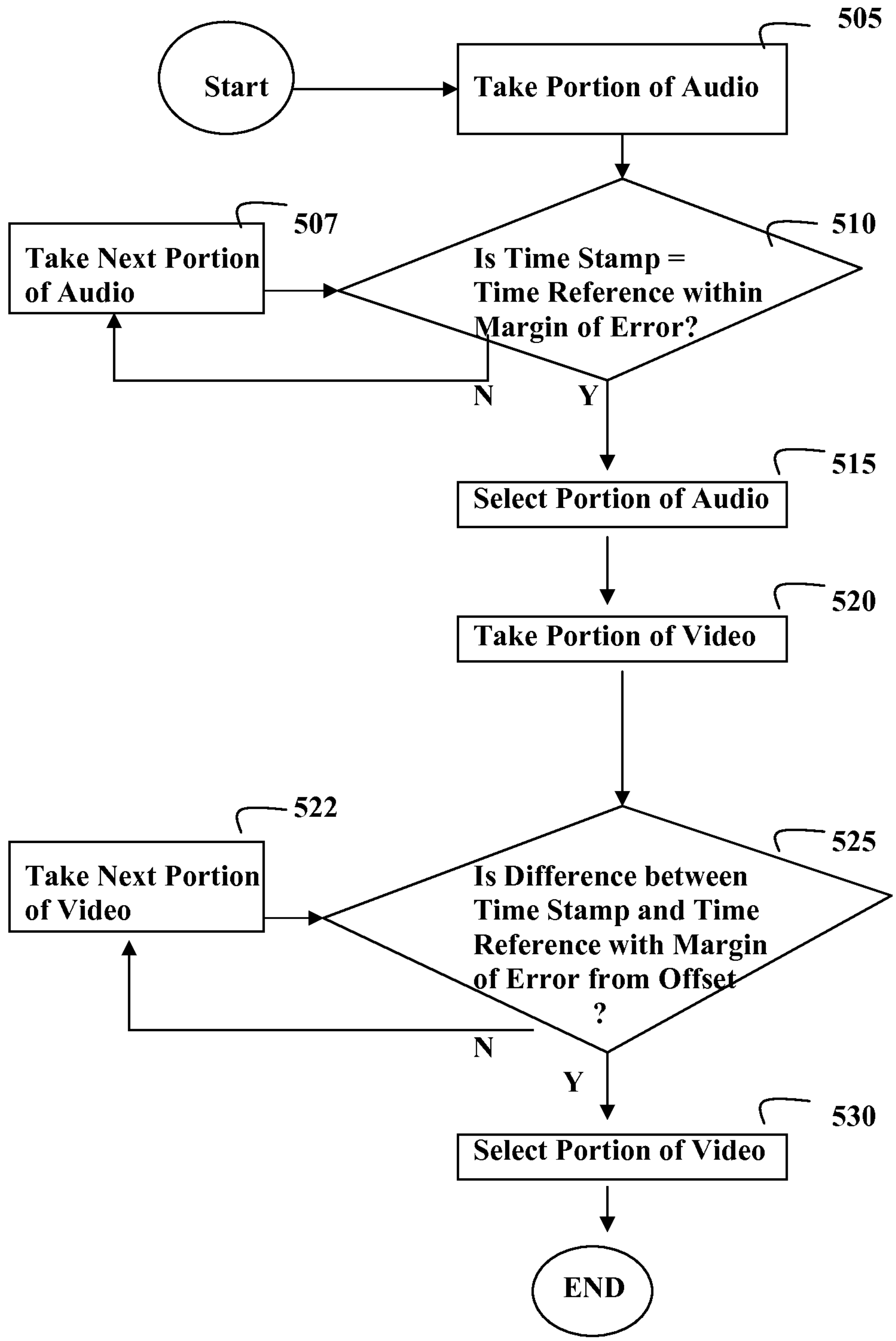

505
Start
Take Portion of Audio
507
Take Next Portion of Audio
510
Is Time Stamp = Time Reference within Margin of Error?
N
Y
515
Select Portion of Audio
520
Take Portion of Video
522
Take Next Portion of Video
525
Is Difference between Time Stamp and Time Reference with Margin of Error from Offset ?
N
Y
530
Select Portion of Video
END

FIGURE 3

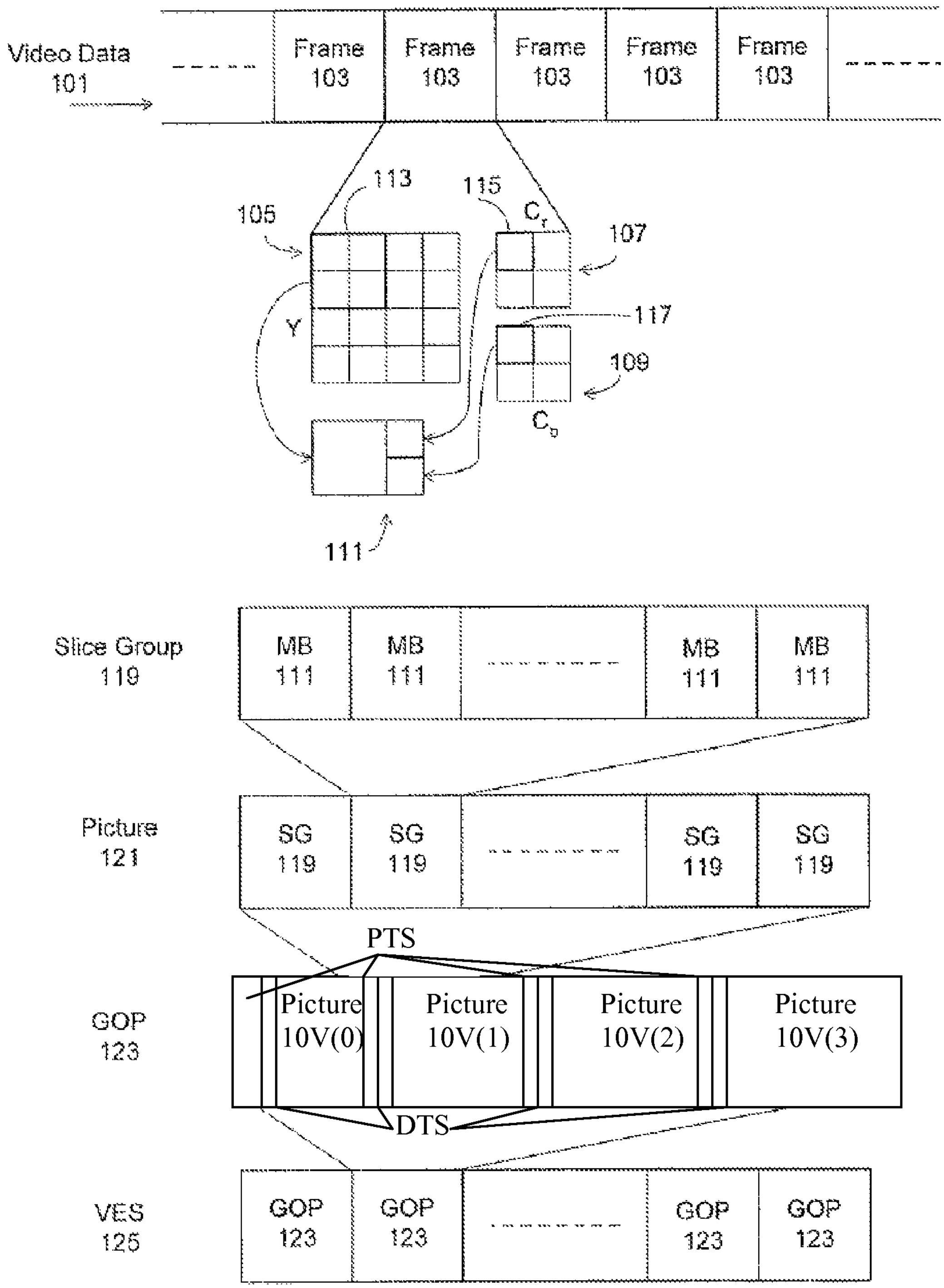

Video Data
101
Frame
103
Frame
103
Frame
103
Frame
103
Frame
103
113
115
105
C_r
107
Y
117
109
C_b
111
Slice Group
119
MB
111
MB
111
MB
111
MB
111
Picture
121
SG
119
SG
119
SG
119
SG
119
PTS
GOP
123
Picture
10V(0)
Picture
10V(1)
Picture
10V(2)
Picture
10V(3)
DTS
VES
125
GOP
123
GOP
123
GOP
123
GOP
123

FIGURE 4A

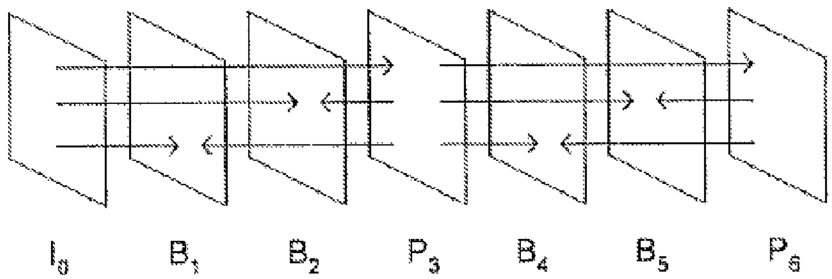


FIGURE 4B

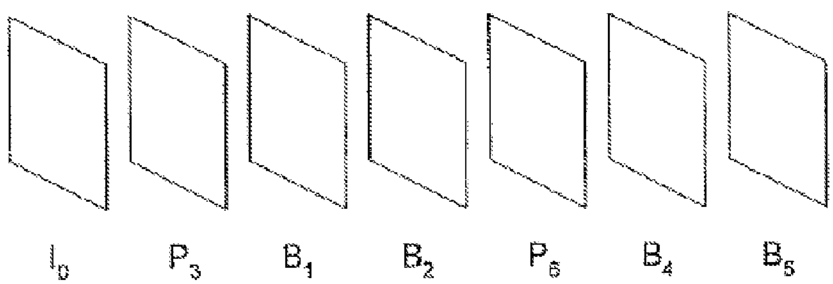


FIGURE 4C

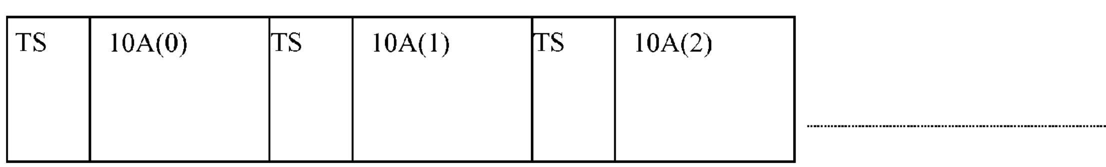


FIGURE 4D

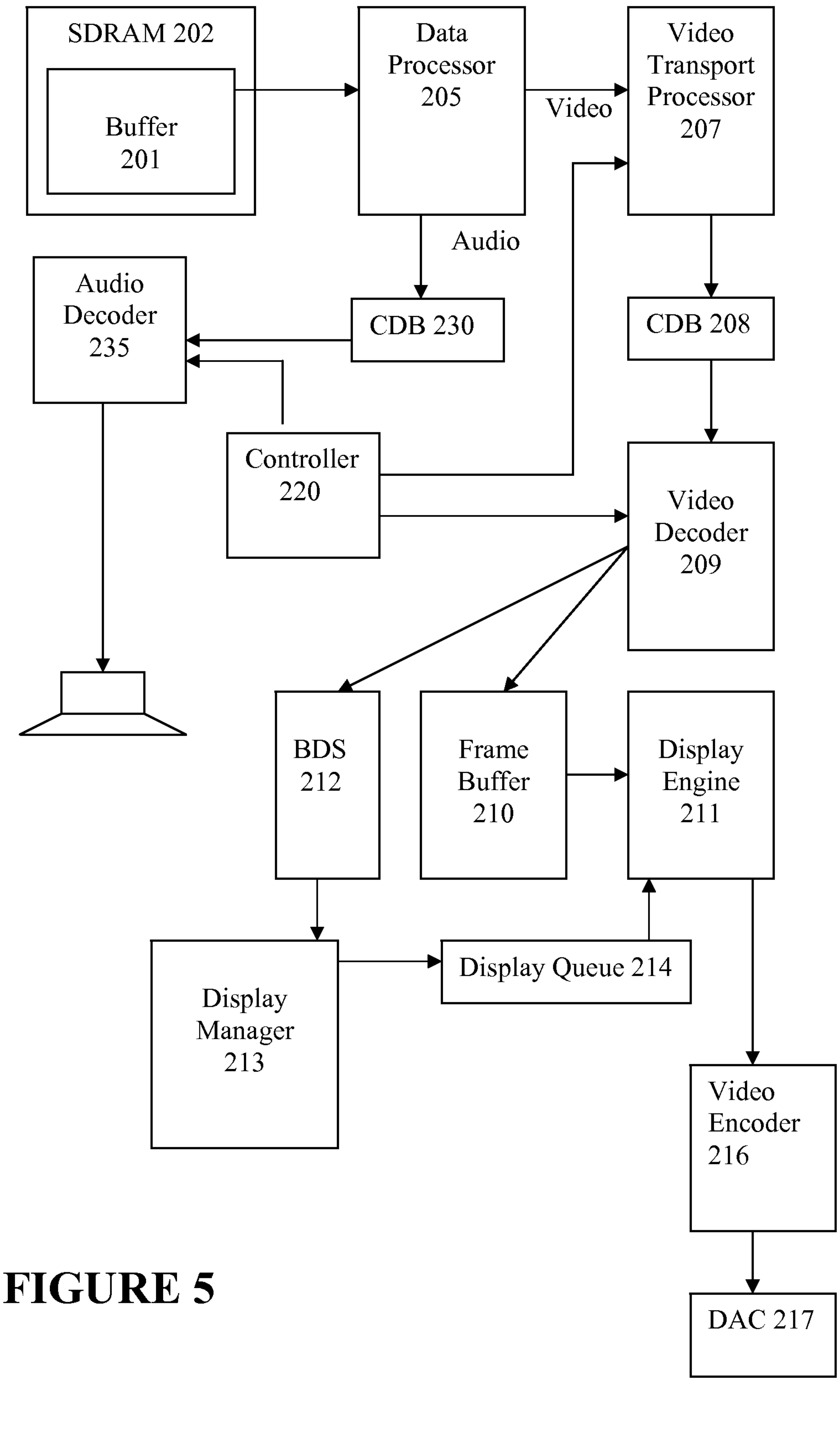

SDRAM 202
Buffer 201
Data Processor 205
Video
Video Transport Processor 207
Audio
Audio Decoder 235
CDB 230
CDB 208
Controller 220
Video Decoder 209
BDS 212
Frame Buffer 210
Display Engine 211
Display Queue 214
Display Manager 213
Video Encoder 216
DAC 217

FIGURE 5

DISPLAYING AUDIO DATA AND VIDEO DATA

RELATED APPLICATIONS

This application is a continuation of copending U.S. utility application Ser. No. 11/017,000, entitled, "System and Method for Audio and Visual Synchronization," filed Dec. 20, 2004 and issued as U.S. Pat. No. 8,331,345 on Dec. 11, 2012, which is a continuation-in-part of U.S. utility application Ser. No. 10/259,032, entitled "Handling Video Transition Errors in Video on Demand Systems," filed Sep. 27, 2002 and issued as U.S. Pat. No. 7,953,194 on May 31, 2011, each of which are each entirely incorporated herein by reference.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[Not Applicable]

MICROFICHE/COPYRIGHT REFERENCE

[Not Applicable]

BACKGROUND OF THE INVENTION

Common audio and video encoding standards, such as MPEG-1, Layer 3 (audio) and MPEG-2, or H.264 (video), significantly compress audio and video data, respectively. This allows for the transmission and storage of the audio and video data with less bandwidth and memory.

In general, the video encoding standards operate on the pictures forming the video. A video comprises a series of pictures that are captured at time intervals. When the pictures are displayed at corresponding time intervals in the order of capture, the pictures simulate motion.

Generally, audio signals are captured in frames representing particular times. During playback, the frames are played at corresponding time intervals in the order of capture. In multi-media applications, it is desirable to play the audio and video, such that audio frames and pictures that were captured during the same time interval are played at approximately the same time interval.

Encoding standards use time stamps to facilitate playback of audio and video at appropriate times. A decoder compares the times stamps to a system clock to determine the appropriate portions of the audio and video to play. The time stamps are generally examined prior to decoding, because decoding consumes considerable processing power.

In many decoders, there are separate audio and video decoding portions. The audio and video decoding portions take different amounts of time to decode the audio and video data. Generally, the video decoding portion takes longer time to decode the video data. Accordingly, decoding and playing audio and video data with the same time stamp can cause a time lag between the audio and video. This is undesirable to the user.

Further limitations and disadvantages of conventional and traditional systems will become apparent to one of skill in the art through comparison of such systems with the invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

Presented herein is a system, method, and apparatus for audio and video synchronization.

In one embodiment, there is presented a method for displaying audio data and video data. The method comprises examining a plurality of portions of the audio data, each of said plurality of portions of audio data associated with a time stamp; examining a plurality of portions of the video data, each of said plurality of portions of the video data associated with a time stamp; decoding one of the portions of the video data; decoding one of the portions of the audio data while decoding the one of the portions of the video data; and wherein the difference between the time stamp associated with the one of the portions of the video data and the time stamp associated with the one of the portions of the audio data is within a certain margin of error from a predetermined offset.

In another embodiment, there is presented a decoder system for displaying audio data and video data. The decoder system comprises one or more controllers, an audio decoder, and a video decoder. The one or more controllers examine a plurality of portions of the audio data, where each of said plurality of portions of audio data is associated with a time stamp and examines a plurality of portions of the video data, and where each of said plurality of portions of the video data is associated with a time stamp. The audio decoder decodes one of the portions of the audio data while the video decoder decodes one of the portions of the video data. The difference between the time stamp associated with the one of the portions of the video data and the time stamp associated with the one of the portions of the audio data is within a certain margin of error from a predetermined offset.

These and other advantageous and novel features as well as details of illustrated embodiments will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a block diagram of exemplary video and audio data;

FIG. **2** is a block diagram of an exemplary decoder system for decoding video and audio data in accordance with an embodiment of the present invention;

FIG. **3** is a flow diagram for decoding portions of audio and video data in accordance with an embodiment of the present invention;

FIG. **4**A is a block diagram describing encoding of video data in accordance with the MPEG-2 standard;

FIG. **4**B is a block diagram describing temporal compression in accordance with the MPEG-2 standard;

FIG. **4**C is a block diagram describing an exemplary decode order;

FIG. **4**D is a block diagram describing exemplary encoded audio data; and

FIG. **5** is a block diagram of an exemplary decoder system in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. **1**, there is illustrated a block diagram describing exemplary encoded video **10**V and audio data **10**A. In general, the video encoding standards operate on the pictures forming the video. A video comprises a series of pictures **10**V(**0**) . . . **10**V(n) that are captured at time intervals. When the pictures are displayed at corresponding time intervals in the order of capture, the pictures simulate motion.

Audio data is captured in frames **10**A(**0**) . . . **10**A(n) representing particular times. During playback, the frames are played at corresponding time intervals in the order of capture.

In multi-media applications, it is desirable to play the audio and video, such that audio frames and pictures that were captured during the same time interval are played at approximately the same time interval.

Time stamps facilitate playback of audio and video at appropriate times. Portions of the video data, such as pictures **10**V( ) and frames **10**A( ) are associated with time stamps **15**V( ), **15**A( ), indicating the time that the particular picture **10**V( ) or frame **10**A( ) is to be displayed.

Referring now to FIG. **2**, there is illustrated a block diagram of a decoder system in accordance with an embodiment of the present invention. The decoder system **20** comprises a video decoder **25**, an audio decoder **30**, and a controller **35**. The controller **35** examines portions of the audio data **10**A( ) and video data **10**V( ).

As noted above, each of the portions of audio data and video data are associated with a time stamp **15**A( ), **15**V( ). The video decoder **25** decodes one of the portions of the video data **10**V( ) while the audio decoder **30** decodes one of the portions of the audio data **10**A( ). The difference between the time stamp **15**V( ) associated with the portion of the video data decoded by the video decoder **25**, and the time stamp **15**A( ) associated with the portions of the audio data decoded by the audio decoder **30** is within a certain margin of error from a predetermined offset.

According to certain aspects of the present invention, the predetermined offset can be based on the difference in times taken by the video decoder **25** to decode a portion of the video data **10**V( ) and taken by the audio decoder **30** to decode a portion of the audio data **10**A( ).

Generally, the video decoder **30** can take a longer time to decode a portion of video data. Thus, if the decoding of the portions of the audio data (i.e., are decoded later) having approximately equal time stamps **15** by an offset (the difference between decoding times of audio and video decoders), portions of the video **10**V( ) and audio **10**A( ) to be played at the same time become available for play at the same time. The foregoing can be achieved by decoding a video portion **10**V( ) and an audio portion **10**A( ) where the audio portion **10**A( ) is associated with a time stamp that exceeds the time stamp associated with the video portion **10**V( ) by the offset.

According to certain aspects of the invention, the decoder system can also include a system clock **40** for providing a time reference, and memory **41** for storing the audio and video data prior to decoding. The controller **35** compares the time stamps **15**V( ) associated with the video data and the controller **36** compares the time stamps **15**A( ) associated with the audio data to the time reference. The controller **35** then selects the portion of the video data **10**V( ) associated with the time stamp **15**V( ) that exceeds the time reference by within a margin of error from the offset. The controller **36** selects the portion of the audio data associated with the time stamp within the margin of error from the time reference.

Referring now to FIG. **3**, there is illustrated a flow diagram for decoding portions **10**V( ) of the video data and portions **10**A( ) of the audio data. At **505**, a portion of the audio data **10**A(n) is taken. At **510**, the time stamp TS for the portion **10**A(n) of audio data is examined and compared to a reference time, to determine if the time stamp **15**A(n) associated with the portion **10**A(n) of the audio data is within a margin of error from the reference time. If the portion **10**A(n) of the audio data is within the margin of error, the portion **10**A(n) of the audio data is selected (**515**). If not, the next portion **10**A(n+1) of the audio data is taken at **507**, and **510-515** are repeated.

At **520**, a portion **10**V(n) of the video data is examined. At **525**, the time stamp **15**V(n) for the portion of the video data is compared to a reference time, to determine if the time stamp exceeds the reference time within a margin of error from an offset. If the time stamp **15**V(n) exceeds the reference time within a margin of error from the offset, the portion **10**V(n) is selected at **525**. If not, the next portion **10**V(n+1) is taken at **522**.

At **530**, the portion **10**A( ) of the audio data selected during **515**, and the portion **10**V( ) of the video data selected during **525** are decoded together at **535**. It is noted that the difference between the times stamp **15**V( ) for the portion **10**V( ) of the video data decoded during **535** and the time stamp **15**A( ) for the portion **15**A( ) of the audio data decoded during **535** are within the margin of error from the predetermined offset.

The present invention will now be described in the context of an exemplary audio encoding standard, MPEG-1, Layer 2, and video encoding standard, MPEG-2. It is understood, however, that the present invention is not limited to the foregoing standards, and can be practiced with a variety of different encoding standards.

MPEG-2 and MPEG-1, Layer 2

FIG. **4**A illustrates a block diagram of an exemplary Moving Picture Experts Group (MPEG) encoding process of video data **10**, in accordance with an embodiment of the present invention. The video data **10**V comprises a series of pictures **10**V( ) Each picture **10**V( ) comprises two-dimensional grids of luminance Y, **105**, chrominance red C_r, **107**, and chrominance blue C_b, **109**, pixels.

The two-dimensional grids are divided into 8×8 blocks, where a group of four blocks or a 16×16 block **113** of luminance pixels Y is associated with a block **115** of chrominance red C_r, and a block **117** of chrominance blue C_b pixels. The block **113** of luminance pixels Y, along with its corresponding block **115** of chrominance red pixels C_r, and block **117** of chrominance blue pixels C_b form a data structure known as a macroblock **111**. The macroblock **111** also includes additional parameters, including motion vectors, explained hereinafter. Each macroblock **111** represents image data in a 16×16 block area of the image.

The data in the macroblocks **111** is compressed in accordance with algorithms that take advantage of temporal and spatial redundancies. For example, in a motion picture, neighboring pictures **10**V( ) usually have many similarities. Motion causes an increase in the differences between pictures, the difference being between corresponding pixels of the pictures, which necessitate utilizing large values for the transformation from one picture to another. The differences between the pictures may be reduced using motion compensation, such that the transformation from picture to picture is minimized. The idea of motion compensation is based on the fact that when an object moves across a screen, the object may appear in different positions in different pictures, but the object itself does not change substantially in appearance, in the sense that the pixels comprising the object have very close values, if not the same, regardless of their position within the picture. Measuring and recording the motion as a vector can reduce the picture differences. The vector can be used during decoding to shift a macroblock **111** of one picture to the appropriate part of another picture, thus creating movement of the object. Hence, instead of encoding the new value for each pixel, a block of pixels can be grouped, and the motion vector, which determines the position of that block of pixels in another picture, is encoded.

Accordingly, most of the macroblocks **111** are compared to portions of other pictures **10**V( ) (reference pictures). When an appropriate (most similar, i.e. containing the same object (s)) portion of a reference picture **10**V( ) is found, the differences between the portion of the reference picture **10**V( ) and the macroblock **111** are encoded. The location of the portion in the reference picture **10**V( ) is recorded as a motion vector. The encoded difference and the motion vector form part of the data structure encoding the macroblock **111**. In the MPEG-2 standard, the macroblocks **111** from one picture **10**V( ) (a predicted picture) are limited to prediction from portions of no more than two reference pictures **10**V( ). It is noted that pictures **10**V( ) used as a reference picture for a predicted picture **10**V( ) can be a predicted picture **10**V( ) from another reference picture **10**V( ).

The macroblocks **111** representing a picture are grouped into different slice groups **119**. The slice group **119** includes the macroblocks **111**, as well as additional parameters describing the slice group. Each of the slice groups **119** forming the picture form the data portion of a picture structure **10**V( ). The picture **10**V( ) includes the slice groups **119** as well as additional parameters that further define the picture **10**V( ). Among the parameters are a presentation time stamp PTS, and decode time stamp DTS.

I_0, B_1, B_2, P_3, B_4, B_5, P_6, B_7, B_8, P_9, in FIG. **4**B, are exemplary pictures. The arrows illustrate the temporal prediction dependence of each picture. For example, picture B_2 is dependent on reference pictures I_0, and P_3. Pictures coded using temporal redundancy with respect to exclusively earlier pictures of the video sequence are known as predicted pictures (or P-pictures), for example picture P_3 is coded using reference picture I_0. Pictures coded using temporal redundancy with respect to earlier and/or later pictures of the video sequence are known as bi-directional pictures (or B-pictures), for example, pictures B_1 is coded using pictures I_0 and P_3. Pictures not coded using temporal redundancy are known as I-pictures, for example I_0. In the MPEG-2 standard, I-pictures and P-pictures are also referred to as reference pictures.

The foregoing data dependency among the pictures requires decoding of certain pictures prior to others. Additionally, the use of later pictures as reference pictures for previous pictures requires that the later picture is decoded prior to the previous picture. As a result, the pictures cannot be decoded in temporal display order, i.e. the pictures may be decoded in a different order than the order in which they will be displayed on the screen. Accordingly, the pictures are transmitted in data dependent order, and the decoder reorders the pictures for presentation after decoding. I_0, P_3, B_1, B_2, P_6, B_4, B_5, P_9, B_6, B_7, in FIG. **4**C, represent the pictures in data dependent and decoding order, different from the display order seen in FIG. **4**B. A decoder can use the decode time stamp DTS and the presentation time stamp PTS to determine when to decode and display the pictures **10**V( ).

Referring again to FIG. **4**A, the pictures are then grouped together as a group of pictures (GOP) **123**. The GOP **123** also includes additional parameters further describing the GOP. Groups of pictures **123** are then stored, forming what is known as a video elementary stream (VES) **125**. The VES **125** is then packetized to form a packetized elementary sequence. The packetized elementary stream includes parameters, such as the decode time stamp and the presentation time stamp. The packetized elementary stream is then further packetized into fixed length packets, each of which are associated with a transport header, forming what are known as transport packets. The packetized elementary stream can also be encrypted.

The transport packets can be multiplexed with other transport packets carrying other content, such as another video elementary stream **125** or an audio elementary stream. The multiplexed transport packets form what is known as a transport stream. The transport stream is transmitted over a communication medium for decoding and displaying.

Referring now to FIG. **4**D, there is illustrated a block diagram describing the encoding of an audio signal **10**A. The audio signal **10**A is sampled and digitized at various time intervals. The samples are divided into frames **10**A( ) representing a larger time interval. Each of the frames **10**A( ) are separately encoded, and transmitted to a decoder. The frames **10**A( ) include a time stamp TS indicating the time that the frame **10**A( ) should be played. A decoder can use the PTS to play the appropriate frames at the appropriate times.

Referring now to FIG. **5**, there is illustrated a block diagram of an exemplary circuit for decoding the compressed audio data **10**A( ) and video data **10**V( ) in accordance with an embodiment of the present invention. A buffer **201** within a Synchronous Dynamic Random Access Memory (SDRAM) **202** receives a transport stream. The buffer **201** can receive the transport stream, either from a storage device **204**, such as, for example, a hard disc or a DVD, or a communication channel **206**.

A data transport processor **205** demultiplexes the transport stream into audio transport streams and video transport streams. The data transport processor **205** provides the audio transport stream to an audio portion and the video transport stream to a video transport processor **207**.

The audio portion includes a compressed data buffer **230** and an audio decoder **235**. The compressed data buffer **230** stores frames of audio data **10**A( ). The audio decoder **235** decodes the frames of audio data **10**A( ) for play on a speaker.

The video transport processor **207** parses the video transport stream and recovers the video elementary stream. The video transport processor **207** writes the video elementary stream to a compressed data buffer **208**. A video decoder **209** reads the video elementary stream from the compressed data buffer **208** and decodes the video. The video decoder **209** decodes the video on a picture by picture basis. When the video decoder **209** decodes a picture, the video decoder **209** writes the picture to a frame buffer **210**.

The video decoder **209** receives the pictures in decoding order. However, as noted above, the decoding and displaying orders can be different. Accordingly, the decoded pictures are stored in frame buffers **210** to be available at display time. At display time, display engine **211** scales the video picture, renders the graphics, and constructs the complete display. Once the display is ready to be presented, it is passed to a video encoder **216** where it is converted to analog video using an internal digital to analog converter (DAC). The digital audio is converted to analog in an audio digital to analog converter (DAC) **217**.

The frame buffers **210** also allow the video decoder **209** to predict predicted pictures from reference pictures. The decoder **209** decodes at least one picture, I_0, B_1, B_2, P_3, B_4, B_5, P_6, B_7, B_8, P_9, during each frame display period, in the absence of Personal Video Recording (PVR) modes when live decoding is turned on. Due to the presence of the B-pictures, B_1, B_2, the decoder **209** decodes the pictures, I_0, B_1, B_2, P_3, B_4, B_5, P_6, B_7, B_8, P_9 in an order that is different from the display order. The decoder **209** decodes each of the reference pictures, e.g., I_0, P_3, prior to each picture that is predicted from the reference picture. For example, the decoder **209** decodes I_0, B_1, B_2, P_3, in the order, I_0, P_3, B_1, and B_2. After decoding I_0 and P_3, the decoder **209** applies the offsets and displacements stored in B_1 and B_2, to the decoded I_0 and P_3, to decode B_1 and B_2. The frame buffers **210** store the decoded pictures, I_0 and P_3, in order for the video decoder **209** to decode B_1 and B_2.

The video decoder **209** also writes a number of parameters associated with each picture in a buffer descriptor structure **212**. Each frame buffer **210** is associated with a buffer descriptor structure **212**. The buffer descriptor structure **212** associated with a frame buffer **210** stores parameters associated with the picture stored in the frame buffer **210**. The parameters can include, for example presentation time stamps.

A display manager **213** examines the buffer descriptor structures, and on the basis of the information therein, determines the display order for the pictures. The display manager **213** maintains a display queue **214**. The display queue **214** includes identifiers identifying the frame buffers **210** storing the pictures to be displayed. The display engine **211** examines the display queue **214** to determine the next picture to be displayed.

The display manager **213** can determine the next picture to be displayed by examining the PTS parameters associated with the pictures. The display manager **213** can compare the PTS values associated with pictures to a system clock reference (SCR) to determine the ordering of the pictures for display.

Alternatively, the display manager **213** can also determine the order of the pictures to be displayed by examining the type of pictures decoded. In general, when the video decoder **209** decodes a B-picture, the B-picture is the next picture to be displayed. When the video decoder **209** decodes an I-picture or P-picture, the display manager **213** selects the I-picture or P-picture that was most recently stored in the frame buffer **210** to be displayed next.

A particular one of the frame buffers **210** stores B-pictures, while two other frame buffers **210** store I-pictures and P-pictures. When the video decoder **209** decodes a B-picture, the video decoder **209** writes the B-picture to the particular frame buffer **210** for storing B-pictures, thereby overwriting the previously stored B-picture. When the video decoder **209** decodes an I-picture or a P-picture, the video decoder **209** writes the I-picture or P-picture to the frame buffer **210** storing the I-picture or P-picture that has been stored for the longest period of time, thereby overwriting the I-picture or P-picture.

The circuit also includes a controller **220** that acts as the master for the data transport processor **205**, the video transport processor **207**, the video decoder **209**, the display engine **211**, and the display manager **213**.

As noted above, the frames **10**A( ) of audio data and pictures of video data **10**V( ) are associated with a time stamp TS, PTS, DTS. The video decoder **209** decodes one of the pictures **10**V( ) of the video data while the audio decoder **235** decodes one of the frames of the audio data **10**A( ). The difference between the decode time stamp DTS associated with the picture **10**V( ) of the video data decoded by the video decoder **209**, and the time stamp TS associated with the frames **10**A( ) of the audio data decoded by the audio decoder **235** is within a certain margin of error from a predetermined offset.

According to certain aspects of the present invention, the predetermined offset can be based on the difference in times taken by the video decoder **209** to decode a picture of the video data **10**V( ) and taken by the audio decoder **235** to decode a frame of the audio data **10**A( ).

Generally, the video decoder **209** can take a longer time to decode a picture **10**V( ) of video data. Thus, if decoding the picture **10**V( ) of the video data leads (i.e., are decoded earlier) the decoding of the frames **10**A( ) of the audio data (i.e., are decoded later) having approximately equal DTSs by an offset (the difference between decoding times of audio and video decoders), pictures of the video **10**V( ) and frames of the audio data **10**A( ) to be played at the same time become available for play at the same time. The foregoing can be achieved by decoding a picture **10**V( ) and an audio portion **10**A( ) where the audio portion **10**A( ) is associated with a time stamp that exceeds the time stamp associated with the video portion **10**V( ) by the offset.

According to certain aspects of the invention, the decoder system can also include a system clock **240** for providing a time reference. The controller **220** compares the time stamps DTS or PTS associated with pictures **10**V( ) of the video data and the time stamps TS associated with frames **10**A( ) of the audio data to the time reference. The controller **220** then selects the audio data **10**A( ) associated with the time stamp DTS or PTS that exceeds the time reference by within a margin of error from the offset. The controller **220** selects the frame **10**V( ) of the video data associated with the time stamp within the margin of error from the time reference.

The decoder system(s) as described herein may be implemented as a board level product, as a single chip, application specific integrated circuit (ASIC), or with varying levels of the system integrated on a single chip with other portions of the system as separate components. The degree of integration of the monitoring system may primarily be determined by speed of incoming MPEG packets, and cost considerations. Because of the sophisticated nature of modern processors, it is possible to utilize a commercially available processor, which may be implemented external to an ASIC implementation of the present system. Alternatively, if the processor is available as an ASIC core or logic block, then the commercially available processor can be implemented as part of an ASIC device wherein the memory storing instructions is implemented as firmware. In one representative embodiment, the decoder system can be implemented as a single integrated circuit (i.e., a single chip design).

While the invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the invention. In addition, many modifications may be made to adapt particular situation or material to the teachings of the invention without departing from its scope. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

The invention claimed is:

1. A method for displaying audio data and video data, the method comprising:

comparing time stamps associated with portions of video data with a predetermined offset to a clock reference;

comparing time stamps associated with portions of audio data to the clock reference;

examining a time stamp of a portion of the audio data, the portion of the audio data selected for decoding based on the comparison between the time stamps associated with the audio data and the clock reference;

comparing the time stamp of the portion of the audio data with a time stamp of a portion of the video data, the portion of the video data selected for decoding based on the comparison between the time stamps associated with the video data and the clock reference;

determining that a difference between the time stamp associated with the portion of the video data and the time stamp associated with the portion of the audio data is within a certain margin of error from the predetermined offset; and

decoding the portion of the audio data while decoding the portion of the video data, responsive to the determination that the difference is within the certain margin of error from the predetermined offset.

2. The method of claim 1, wherein the predetermined offset is a function of a difference between a time for decoding video data and a time for decoding audio data.

3. The method of claim 1, wherein the time stamp for the portion of the video data and the time stamp for the portion of the audio data are offset such that decoding of the portion of the video data ends concurrently with decoding of the portion of the audio data.

4. The method of claim 1, wherein the time stamp associated with the portion of the video data comprises a decode time stamp.

5. The method of claim 1, wherein the time stamp associated with the portion of the audio data exceeds the time stamp associated with the portion of the video data.

6. The method of claim 1, further comprising storing the audio and video data.

7. A system for displaying audio data and video data, the system comprising:

one or more controllers operable to compare time stamps associated with portions of video data with a predetermined offset to a clock reference, compare time stamps associated with portions of the audio data to the clock reference, examine examining a time stamp of a portion of the audio data selected for decoding based on the comparison between the time stamps associated with the audio data and the clock reference, and

compare the time stamp of the portion of the audio data with a time stamp of a portion of the video data, the portion of the video data selected for decoding based on the comparison between the time stamps associated with the video data and the clock reference,

the one or more controllers further operable to determine that a difference between the time stamp associated with the portion of the video data and the time stamp associated with the portion of the audio data is within a certain margin of error from the predetermined offset;

an audio decoder operable to decode the portion of the audio data, responsive to the determination that the difference is within the certain margin of error from the predetermined offset; and

a video decoder operable to decode the portion of the video data while the audio decoder decodes the portion of the audio data, responsive to the determination that the difference is within the certain margin of error from the predetermined offset.

8. The system of claim 7, wherein the predetermined offset is a function of a difference between a time for decoding video data and a time for decoding audio data.

9. The system of claim 7, wherein the time stamp for the portion of the video data and the time stamp for the portion of the audio data are offset such that decoding of the portion of the video data ends concurrently with decoding of the portion of the audio data.

10. The system of claim 7, wherein the time stamp associated with the portion of the video data comprises a decode time stamp.

11. The system of claim 7, wherein the time stamp associated with the portion of the audio data exceeds the time stamp associated with the portion of the video data.

12. The system of claim 7, further comprising:

a system clock operable to provide a time reference,

wherein the one or more controllers compare time stamps associated with portions of the video data with the predetermined offset to the time reference and compare time stamps associated with portions of the audio data to the time reference.

13. The system of claim 7, further comprising a memory for storing the audio data and video data.

14. A non-transitory computer-readable medium having executable instructions for displaying audio data and video data, the instructions operable to cause a processor to:

comparing time stamps associated with portions of video data with a predetermined offset to a clock reference;

comparing time stamps associated with portions of audio data to the clock reference;

examine a time stamp of a portion of the audio data, the portion of the audio data selected for decoding based on the comparison between the time stamps associated with the audio data and the clock reference;

compare the time stamp of the portion of the audio data with a time stamp of a portion of the video data, the portion of the video data selected for decoding based on the comparison between the time stamps associated with the video data and the clock reference;

determine that a difference between the time stamp associated with the portion of the video data and the time stamp associated with the portion of the audio data is within a certain margin of error from a predetermined offset; and

decode the portion of the audio data while decoding the portion of the video data, responsive to the determination that the difference is within the certain margin of error from the predetermined offset.

15. The non-transitory computer-readable medium of claim 14, wherein the instructions further comprise instructions operable to cause the processor to compare time stamps associated with portions of the video data with the predetermined offset to a time reference provided by a system clock.

16. The non-transitory computer-readable medium of claim 14, wherein the instructions further comprise instructions operable to cause the processor to compare time stamps associated with portions of the audio data to a time reference provided by a system clock.

* * * * *